Modified Automatic Dependent Surveillance System (M-ADS) For North Sea Helicopters

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The helicopter traffic over the North Sea is performed in uncontrolled airspace over international waters. The lack of radar coverage makes the establishment of controlled airspace difficult. The development of Automatic Dependent Surveillance (ADS) and use of satellite technology for Navigation, Communication and Surveillance (NCS) have made it possible to evaluate Modified Automatic Dependent Surveillance (M-ADS) as a basis for establishing controlled airspace over remote areas without radar coverage.

1. INTRODUCTION.

North Sea air traffic. The Air Traffic Control (ATC) service for Norwegian offshore helicopter traffic has been below an acceptable standard for many years. Norwegian Civil Aviation Authorities (NCAA) have previously taken the position that the offshore traffic is private charter traffic operating in international, uncontrolled airspace and hence outside Norwegian control. With a fleet of nearly 40 offshore helicopters, flying around 40 000 hrs a year, transporting about 900 000 passengers annually, this situation is not acceptable. This situation led to the International Federation of Air Line Pilots Association (IFALPA) in 1991 defining the North Sea area as Black Star Airspace. This means that the standard of Air Traffic Control (ATC) is below International Civil Aviation Organisation (ICAO) accepted standards.

SINTEF report. In 1990, the Norwegian research organisation SINTEF (The Foundation for Scientific and Industrial Technology Research), conducted a safety research project on behalf of Norske Shell and Statoil, with active participation by Helikopter Service (HS). In the report which came out in 1990, significant risk factors associated with helicopter transportation over the North Sea were defined and described. It was concluded that ATC, navigation aids and services made up the second highest risk factor after technical reliability of helicopters.

Helikopter Service safety programme. These findings were no surprise to Helikopter Service, which at the time was evaluating both Health & Usage Monitoring (HUMS) systems, to reduce the risk from low technical reliability, and new navigation systems to reduce the risk from navigational errors. Helikopter Service looked at these evaluations as elements of an active safety programme, working on improvements to helicopter safety. The SINTEF report was a welcomed tool for continued progress in this field. The work so far has resulted

in a company commitment to take a leading role regarding helicopter operations in general, and flight safety in particular. This is the background and the reasons for Helikopter Service taking an active part in the North Sea ADS trial.

Statoil/Kongsberg navigation – traffic surveillance project. The M-ADS project started as a Statoil funded research project performed by Kongsberg Navigation (KN), Norway. The project 'Helicopter traffic surveillance' was initiated by Statoil to investigate the possibilities of tracking offshore helicopters by use of existing and future means. KN concluded in their report that tracking by use of High Frequency (HF) radio was the overall best solution, since satellite communication would be too expensive. This solution was discussed with Statoil, NCAA and helicopter operators in June 1991. Both Statoil and the operators disagreed with KN regarding use of High Frequency radio (HF), and strongly advised KN to look more closely at Satellite Communication (SATCOM). This view was also favoured by NCAA which now had taken a strong interest in the concept. This caused KN to go back to the drawing board and in late 1991 they issued a new proposal, based on SATCOM. By now NCAA had taken over the project and invited Statoil, Shell and Norsk Hydro to participate as sponsors for the project. Since HS had taken an active part in the project definition phase together with KN, HS was invited by NCAA to participate actively in the project, since HS was the best qualified operator with expertise within avionic engineering and operational involvement in GPS evaluation.

2. GLOBAL POSITIONING SYSTEM (GPS). HS has continuously monitored the development of navigation systems and, during the 1980s, was a strong supporter of a Norwegian Loran-C chain. However, due to political reasons this chain was never implemented in the 1980s (but *was* implemented in 1992, 5 years too late), and HS initiated an evaluation programme to consider various types of navigation systems/sensors, which in 1990 also included GPS. In 1990 HS installed Global Wulfsberg GNS 500A-5 with GPS in the S-61N fleet, and in 1991 we installed GPS sensors in AS 332L equipped with Racal RNAV 2 navigation systems. Already in mid 1991, with only 16 satellites operational, we had 24 hrs with 2-dimensional navigation coverage (with altimeter aiding), and our GPS evaluation results showed that the GPS navigation system already was far superior to the other navigation systems, including Omega/VLF, Loran-C, Doppler and Decca, regarding navigation accuracy and reliability. Since October 1992, with 19 satellites operational at that time, we have had 24-hr, 3-dimensional GPS navigation coverage. HS policy is to install GPS navigation systems in all aircraft. By mid 1993, 90% of the fleet was equipped with GPS and HS is now the most experienced GPS user operating over the North Sea. Since 1997 all HS helicopters have been equipped with GPS. The full 24-satellite GPS system was declared Initially Operationally Capable (IOC) by the US Department of Defense (USDoD) in late 1993, and was declared Fully Operationally Capable by the USDoD in 1994. The US Federal Aviation Administration (FAA) approved the system as a supplemental navigation system in US airspace in early 1994. USDoD and FAA are committed to the support of civil use of the GPS system, and its applications, including DGPS, are accelerating at a fast pace worldwide.

3. AUTOMATIC DEPENDENT SURVEILLANCE (ADS). The new ICAO

Future Air Navigation System (FANS) concept includes use of satellite technology for navigation and communication. Up to now, transoceanic flights have relied on HF radio for communication. This has resulted in different kinds of communication problems, since HF is susceptible to atmospheric disturbances. The FANS concept includes Automatic Dependent Surveillance (ADS) which is a system that automatically transmits position reports and other messages like HUMS data, information about passengers/cargo and traffic information/clearances from the aircraft to ATC and vice versa, *via* International Maritime Satellite (INMARSAT). By use of ADS, the shortcomings of VHF and HF radio communications are resolved. This system has been under evaluation for some time. Likewise, satellite relay of telephone messages to/from aircraft are being implemented. The ICAO decision on FANS/ADS combined with the Statoil/Kongsberg Navigation study of Helicopter Traffic Surveillance, triggered NCAA's interest in developing a North Sea ADS trial; hence the Modified ADS (M-ADS) system. NCAA saw the M-ADS concept having the potential to become a substitute for radar surveillance in the North Sea, and hence to upgrade parts of the airspace from uncontrolled to controlled.

4. MODIFIED AUTOMATIC DEPENDENT SURVEILLANCE (M-ADS).

Operational goals. The purpose of the M-ADS is to provide helicopter surveillance data for maintaining safe separation of helicopters, to allow improved airspace capacity and to permit more efficient operations over the North Sea. This will be accomplished by providing information to the ground-based segment of the M-ADS, the M-ADS processor (M-ADSP), which will enable it to estimate helicopter position, and to make short-term and long-term predictions of where the helicopter will be at any specified future time. The helicopter avionics will provide information on its present position, short-term and long-term intentions, local meterological data, and the occurrence of certain events.

Operational applications. M-ADS is intended to provide automatic periodic position and event-driven reports to the M-ADS processor at ground-specified intervals. Helicopter avionics are installed and/or modified to generate these M-ADS reports. The M-ADSP subsequently processes the information to validate the M-ADS position reports and correlate them with the flight plan.

M-ADS system overview. M-ADS is a service for use by air traffic services (ATS) in which helicopters automatically transmit, *via* a data link, data derived from on-board navigation systems. As a minimum, the data includes three-dimensional position, the corresponding time of the position data, and a Figure of Merit (FOM) that characterises the accuracy of the position data. Additional data may be provided as appropriate. (Adapted from the Future Air Navigation Systems (FANS)/4 Report, Document 9524.)

Airborne components of the M-ADS system. The airborne components of the M-ADS system are as follows:

(i) Pilot interface
(ii) Avionics encompassing the M-ADS function
(iii) Aeronautical Telecommunication Network (ATN) Interface

The M-ADS reports are transmitted automatically without pilot action.

The frequency of reporting is determined by the ground-based M-ADS processor system; however, a capability is provided to permit emergency mode reports to be initiated/terminated by the pilot. The M-ADS capability is supported by avionics equipment that is able to gather helicopter data from on-board systems, format them and pass the messages to the helicopter ATN router for transmission to the relevant air-ground link. On-board equipment is also capable of receiving messages originated by the M-ADSP that define reporting parameters, including report update rate, events and the data fields to be included in the report.

Ground-based components of the M-ADS system. The ground-based components of the M-ADS system include:

(i) ATN interface
(ii) ATS ground-based peer of the airborne M-ADSP
(iii) ATS (controller)

5. M-ADS — PHASE I.

M-ADS project. NCAA invited Statoil, Shell, Norsk Hydro, INMARSAT, Norwegian Telecom and Helikopter Service to participate in a North Sea ADS trial project. Since this was the first known installation of SATCOM equipment in helicopters, certain modifications were necessary. Hence the ADS system was renamed Modified Automatic Dependent System (M-ADS). A complete ADS trial system, including the airborne package for installation in the Sikorsky S-61N helicopter, and a ground station for installation at Eik Ground Earth Station (GES) was supplied by INMARSAT. Norwegian Telecom was responsible for the data transmission from Eik GES to Stavanger ATC. Helikopter Service was responsible for the installation, flight testing and operation of the installed ADS trial system. Statoil, Shell and Norsk Hydro made funds available for the M-ADS trial.

The M-ADS trial project organisation included:

(i) Steering Committee
  NCAA
  Statoil
  Norwegian Telecom
  Norway Technical University
(ii) Project Group
  NCAA
  Norwegian Telecom
  HS
(iii) Reference Group
  Braathens Helicopter
  Helikopter Service
  Mørefly
  Widerøe
  RNoAF
  Statoil
  Shell
  Hydro

M-ADS Installation. The M-ADS package was installed in the S-61N cabin in lieu of two passenger seats. The equipment weighed 80 kg and occasionally one operator was included on the flights. Hence, Statoil lost one to two passengers on the evaluation flights. The system used navigation data from the S-61N GPS system, and a SATCOM antenna was mounted on the aft, top fuselage. The system was fully automatic and needed no interaction by the crew.

M-ADS trial. The test plan called for installation of one M-ADS system in a HS S-61N helicopter, flying out of Bergen on the Statfjord track. The test Phase I was planned to commence in April 1992 and to last three months. Due to some technical problems with the equipment, the installation was delayed and the ADS package was test flown in the beginning of June 1992. The Phase I testing was now underway and was planned to be completed in September 1992; however, several equipment malfunctions caused several delays in the programme. In order to get enough data, the programme had to be stretched to the end of January 1993. During the trial period, approximately 300 operating hours were accumulated and approximately 3000 Automatic Position Reports were sent, of which 2313 were received in Stavanger and London.

M-ADS Test Results. The data received at Stavanger ATC soon showed that there were occasionally missing reports, which had been transmitted every 5 minutes from the helicopter. After measuring the antenna reception characteristics, the antenna diagram showed marked notches caused by masking and reflections of signals. The results clearly indicated that on certain headings the relative position of the INMARSAT satellite coincided with one characteristic notch in the antenna diagram. This resulted in lost data transmissions on the return leg of the Statfjord track. This prompted the project group to decide on evaluating the use of two satellites, including the Atlantic West satellite over South America, in addition to Atlantic East over West Africa. This did not cure the problem, however, due to a coincidence of very strong winds from the west during the test period, which resulted in more helicopter drift and hence caused the antenna diagram notches again to coincide with the satellite relative direction. However, the concept was proven and the test results indicated that there were no major obstacles to prevent a M-ADS concept from being implemented. The major significance of the test results was that the data signals were unaffected by rotor modulation, and with a suitable antenna position the data stream should pass unrestricted.

Conclusion – Phase I. It was concluded that Automatic Dependent Surveillance of North Sea offshore helicopters was feasible and that the M-ADS Phase II should continue.

6. M-ADS – PHASE II.

Project progress. Norsk Forsvarsteknologi (NFT, now Kongsberg Aerospace) was initially given a project definition contract, including the task of preparing a M-ADS system specification. This was completed in 1993. In early 1994, NCAA issued a contract to NFT to develop, test and qualify a M-ADS unit for helicopters. NFT issued a sub-contract to Racal Avionics, UK to produce the SATCOM equipment for NFT, which was responsible for system integration, testing and qualification. Helikopter Service is part of the group of sponsors and was a sub-contractor to Kongsberg Aerospace (KA), being responsible for the engineering

and installation, and together with KA tested the systems. NCAA was responsible for the system infrastructure and certification.

Administration. NCAA, together with KA and the sponsors (Statoil, Shell, Hydro, other Norwegian oil companies and Helikopter Service), are members of a Steering Committee which controlled the development work in Phase II.

NCAA responsibilities – Phase II. NCAA was responsible for:

(i) Project management.
(ii) Quality control.
(iii) Certification of M-ADS.

KA responsibilities. KA was responsible for:

(i) Total system integration, testing and qualification.
(ii) Development of the M-ADS unit according to the approved specification.
(iii) Testing of the M-ADS equipment in cooperation with NCAA and HS.
(iv) The technical and commercial aspects of the sub-contracted SATCOM part of the M-ADS project.

Sponsor responsibilities. The sponsors were responsible for:

(i) Statoil, Shell, Norsk Hydro and Helikopter Service (of which Statoil has the Chair of the Steering Committee) were the launch sponsors for the M-ADS project.
(ii) Additional Norwegian oil companies have joined the sponsor group, and paid a *pro rata* share of the development costs.

HS responsibilities. HS responsibilities included:

(i) Engineering, installation and testing of the M-ADS prototype equipment in Norwegian offshore helicopters.
(ii) Performing operational evaluation/testing of the M-ADS equipment in cooperation with NCAA and KA.

Guarantees.

(i) KA guaranteed the completion of the project.
(ii) NCAA guaranteed certification of the M-ADS equipment.
(iii) NCAA contributed to the international certification of the equipment.

Project status. The Phase II program is now completed and Phase III is starting. Phase III involves installation and certification of M-ADS systems in the remaining offshore helicopter types in Norway.

The development and test aircraft, one Sikorsky S61N and one Eurocopter AS332L1, are flying and NCAA is acquiring data and operational experience. One more AS332L1 was equipped and has been operational since the last quarter of 1997. Further, it has been decided to certify the equipment in one AS332L2 and in one Sikorsky S76C+ in 1998.

The NCAA target date of mandating the M-ADS for offshore helicopters is 1 January 1999.

Project status summary.

(i) Phase III has started.
(ii) The M-ADS unit has been operationally tested.
(iii) The SATCOM units have been operationally tested.
(iv) The M-ADS system is qualified and flying in Sikorsky S-61N and Eurocopter AS332L1 helicopters.
(v) The M-ADS system has been installed in a second AS332L1.
(vi) The M-ADS system is planned to be qualified in an AS332L2 and a Sikorsky S76C+ in 1998.
(vii) The NCAA target date for mandating the M-ADS system for all offshore helicopters is 1 January 1999.

7. WEIGHT/VOLUME.

Box	Volume	Weight (kg)
SDU/RFU	2 MCU (= 1/4 ATR box)	4·5
HPA	2 MCU	4·5
LNA/DIP	280 × 197 × 50 mm	2·0
LGA	275 × 120 × 100 mm	1·0
SATCOM	4 MCU	12·0
NFT M-ADS UNIT	2 MCU	4·0
Total M-ADS	6 MCU	16·0

8. TIMEFRAME.

Phase II development – 3 years	1994–97
M-ADS unit production model	1995
INMARSAT Phase II test	1996–97
M-ADS certification	1996–98
Installation in 3 A/C	1997
Series production	1997–99
Installation in offshore A/C	1997–99
Operational M-ADS	1999

9. PRELIMINARY COST FIGURES.

Preliminary M-ADS equipment cost.

(i) M-ADS production unit cost: 20000 USD
(ii) SATCOM production unit cost: 100000 USD

Preliminary operating cost.

(i) Approx. 25 USD pr. hr.

10. CONCLUSIONS

(i) The M-ADS project Phase I was successfully completed.
(ii) The North Sea M-ADS concept has been proved to work.
(iii) The Phase I report was issued in April 1993.
(iv) The Phase II was completed in 1997.
(v) The Phase III is in progress and will be completed in 1998.

(vi) The M-ADS system is planned to be operational in 1 January 1999.

(vii) The M-ADS system will significantly increase the level of safety by reducing the risk of mid-air collisions over the North Sea, and allow continuous surveillance of the North Sea air traffic.

(viii) The introduction of M-ADS in the North Sea may result in upgrading parts of the airspace from Class G (uncontrolled) to Class E (controlled).

REFERENCES

[1] ICAO document 9524; Future Air Navigation System (FANS) 14 Report.
[2] NCAA report; Modified Automatic Dependent Surveillance Trial, 1993.

KEY WORDS

1. Surveillance. 2. Helicopters. 3. North Sea. 4. ADS.